NASA TECHNICAL MEMORANDUM

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EXPERIMENTALLY-DETERMINED EXTERNAL HEAT LOSS OF AUTOMOTIVE GAS TURBINE ENGINE PRELIMINARY DATA REPORT

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EXPERIMENTALLY-DETERMINED EXTERNAL HEAT LOSS OF AUTOMOTIVE GAS TURBINE ENGINE PRELIMINARY DATA REPORT

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SUMMARY

An external heat balance was conducted on a 150 HP two-shaft automotive gas turbine engine. The engine was enclosed in a calorimeter box and the temperature change of cooling air passing through the box was measured. Cooling airflow ranges of 1.6 to 2.1 lb-per-second and 0.8 to 1.1 lb-per-second were used. The engine housing heat loss increased as the cooling airflow through the calorimeter box was increased, as would be the case in a moving automobile. The heat balance between the total energy input and the sum of shaft power output and various losses compared within 30 percent at engine idle speeds and within 7 percent at full power.

INTRODUCTION

The Lewis Research Center, under an interagency agreement, is assisting the Energy Research and Development Administration (ERDA), formerly EPA, in a program to demonstrate a gas turbine-powered vehicle which will meet or better the 1978 Federal Exhaust Emission Standards. This task is to be accomplished with a minimum impact on vehicle performance, fuel consumption, and cost. As a part of this joint program, a Chrysler sixth generation gas turbine engine has been installed in a Lewis Facility for experimental investigations. Baseline engine performance tests are now in progress. During these tests an engine external heat balance investigation was conducted. The objective of this investigation was to determine the overall external heat loss from this baseline gas turbine engine. The preliminary data obtained in these tests are contained herein. The next phase of this investigation will be to isolate the areas of high heat loss for possible reduction in future engine designs.

APPARATUS AND PROCEDURE

Gas Turbine Engine

The engine being tested is an automotive gas turbine engine designed and built by the Chrysler Corporation. It is a two-shaft machine consisting of a radial compressor, a pair of metallic regenerators, a combustor, a compressor turbine and a power turbine as shown in Figures 1 and 2. The engine design specifications are shown in Table I.

Heat Balance Calorimeter Box

To facilitate the measurement of heat loss from the engine housing, an insulated box was constructed around the engine. This box was placed on 3/4-inch legs to allow ambient room air to enter the box from the bottom. A single 8-inch diameter outlet pipe was located on top of the box over the center of the engine. This outlet pipe was connected via a tee to two flowmeters and two butterfly valves in parallel. The air exhaust system is terminated in the building altitude exhaust system after a control valve as shown schematically in Figure 3. The box and floor were covered with four inches of styrofoam insulation to approach calorimetric conditions. The outlet pipe was insulated between the box and the two air flowmeters.

Instrumentation

In addition to the basic engine instrumentation, the following heat balance instrumentation was utilized for this test:

(1) Engine oil flow rate was measured with a calibrated turbine flowmeter.

(2) Engine oil inlet and outlet temperatures were measured by means of Chromel-Alumel (C/A), thermocouples.

(3) Coolant air inlet temperature to the calorimeter box was measured by averaging the readings of six C/A thermocouples located symmetrically around the inlet to the box at floor level.

(4) Coolant air discharge temperature was measured using four C/A thermocouples equally spaced in the discharge pipe.

(5) Coolant air pressure was measured with a pressure transducer in the outlet line.

(6) Coolant air flow was measured with two turbine flowmeters in the coolant outlet line.

(7) Three C/A thermocouples were inserted circumferentially 120° apart in the same plane, in the engine bulkhead cooling outlet line beneath the engine.

(8) Three C/A thermocouples were inserted circumferentially 120° apart in the same plane in the engine exhaust line downstream of the bulkhead cooling outlet line.

(9) Sixteen C/A thermocouples were attached to the outside engine housing as shown in Figures 4 and 5.

All instrumentation was connected to the CADDE (Central Automatic Digital Data Encoder) central data acquisition system and the data processed on a 360/67 time-sharing computer.

Test Procedure

Anticipating that the airflow over the engine would have an effect on the overall heat loss of the engine to the environement, the tests were planned to include two different air flows while taking engine performance data. The performance data were taken at the minimum SFC points for the following corrected gas generator speeds: 50%, 60%, 70%, 80%, 90%, 95%, and 100%. It was planned to take this data in sequence, first at a low airflow and then at a high airflow. Due to a malfunction of a flowmeter, a third run had to be taken to fill in the data that was missed and, therefore, the readings were not sequential. Achieving steady-state temperatures in the system was a problem due to the large mass of the engine and calorimeter box. To assure that steady-state temperatures had been reached, a series of four to five data readings were taken at five to ten-minute intervals for each test condition. During the testing no attempt was made to control engine inlet oil temperature. This was later found to have an effect on the heat loss from the oil system, QO. The outside ambient air conditions were cold and no provision was made to heat the engine inlet air. As a result the actual engine temperatures were somewhat reduced although the engine was operated at corrected inlet conditions. This fact could also have an effect on the heat loss data. The fuel used for these tests was unleaded gasoline as specified by EPA in Table II.

DATA CALCULATIONS

$$\text{Heat Balance} = [QHF + QHA - (QEXH + QSH + QO + QHL + QBP)]$$

$$HTB = \frac{[QHF + QHA - (QEXH + QSH + QO + QHL + QBP)] \times 100}{QHF}$$

$$\text{Total Heat Loss Measured} = QL_m = QO + QHL = QBP$$

Total Heat Loss Calculated = QL_c = (QHF+QHA) - (QEXH+QSH)

$$\text{QL As Percent of Energy Input} = \frac{QL_{c \text{ or } m}}{QHF} \times 100$$

All data were corrected to standard inlet conditions of 14.696 PSIA and 85°F using the Gas Turbine Engine Test Code SAE J116a, (Ref. 1). Symbols defined in Table III.

TEST DATA

The data included in this report in Table III were taken at steady-state conditions after the engine parameters were stabilized. The data presented were taken at two nominal cooling airflow ranges through the calorimeter box; a high flow range of from 1.6 to 2.1 lb per second, and a low flow range from 0.8 to 1.1 lb per second. The heat losses from the engine housing are shown as a function of percent of gas generator speed for both cooling air flow rates in Figure 6. The difference between the engine housing heat losses at high and low cooling airflow rates is a nearly constant value of approximately 4,000 Btu per hour. This difference in heat loss resulted from the higher velocity of the cooling air over the engine at the higher flow rate. The engine housing temperatures with the calorimeter box removed compare closely with the housing temperatures measured at the low cooling airflow rate. The data at the high cooling airflow rate indicate that the engine heat losses increase due to cooling of the housing as would be the case in a moving automobile.

A heat balance for each data point is shown on the bottom line of each data page. The heat input to the engine from fuel, and inlet air, are listed along with the net shaft horsepower, and the heat losses through the exhaust, housing, oil, and the engine bypass cooling. The last item, HTB, is the calculated percentage difference between the heat input and heat output minus the losses. (See Data Calculations). These values range from 30 percent at 50 percent gas generator speed to 7 percent at 100 percent gas generator speed. The heat loss through the engine bulkhead cooling, QBP, could not be correctly measured. However these values are small and will not greatly affect the overall heat balance.

The bulkhead cooling is supplied by exhaust gases which are circulated through the main engine housing to cool the gas generator turbine area. These gases are then exhausted at the bottom of the engine. The gas temperature rise was measured at the outlet, TBP, but due to the low pressure of the exit gas, a flow measurement could not be made. A measurement of this value, QBP, will be attempted in future testing.

A comparison of measured and calculated values of total heat loss are listed in Table IV. As shown in the Data Calculations section, the measured values include the heat loss from the oil, engine housing, and the

by-pass cooling. The calculated values are determined by subtracting the sum of the exhaust losses and the output shaft horsepower from the energy input. A comparison of these heat loss values is also listed in Table IV as a percentage of the energy input of the fuel.

A comparison of the measured and calculated total heat loss show that in most cases there is good agreement at the higher power output (90% gas generator speed and above). The calculated values, QL_c, show that although the experimental errors in measuring the fuel flow, exhaust gas temperature, and shaft horsepower are small, they can result in creating large numerical differences due to their relative size when compared to the smaller heat loss values. This "difference-of-large-numbers" is apparent at the lower speed and power conditions where the fuel flow and shaft horsepower values are at the low end of the experimental measurement range. On the other hand, the actual measured values of total heat loss, QL_m, are obtained from experimental measurements over a relatively small range of variations. Therefore these measured values are considered to be more accurate than the calculated values.

CONCLUDING REMARKS

An external heat balance was conducted on an automobile gas turbine engine. The gas turbine engine was enclosed in a calorimeter box and the temperature change of cooling air drawn over the engine was measured. Tests were conducted using two ranges of cooling airflow. The results are as follows:

1. The heat balance (total energy input compared with shaft output plus all losses) was within 30 percent at idle speeds and to within 7 percent at full speed and power.

2. The engine housing heat loss increased with cooling flow rate through the calorimeter box.

3. The measured values of total heat loss appear to give more accurate and uniform results over the range of test conditions from idle to full power than the calculated values. This is most likely due to the accumulation of experimental errors in measuring the fuel flow, exhaust gas temperature, and shaft horsepower which are used to determine the calculated values of total heat loss.

The total measured heat loss when expressed as a percentage of the energy input of the fuel is as follows: At 50% speed (idle) the total measured heat loss averaged 13.3% of the fuel energy input, while at 100% speed (full power) the total measured heat loss averaged 8.1% of the fuel energy input.

TABLE I.

ENGINE SPECIFICATIONS

Model	A-128-1
Number	401-403
Maximum Power	150 HP at 3700 RPM
Design Pressure Ratio	4.1
Design Airflow	2.29 lb/sec
Compressor Speed Max.	44,610 RPM
Power Turbine Speed Max.	45,500 RPM
Reduction Gear Ratio	9.6875

TABLE II. - EPA TEST FUEL SPECIFICATION

Item	ASTM Designation	Specification
Octane, Research, Min.	D2699	91-93
Pb. (Orgainc), Gm/U.S. Gal.	D 526	≤.02
Distallation Range	D 86	---
I. B. P., °F	-----	100-115
10 Percent Point, °F	-----	140-150
50 Percent Point, °F	-----	240-250
90 Percent Point, °F	-----	330-340
E. P. °F (max)	-----	425
Sulfur, Wt. Percent Max.	D-1266	0.10
Phosphorous, Theory	-----	0.0
R. V. P. Lb.	D 323	5.5-7.5
Washed Gum (Max) MGM/Gal	D 323	4.0
Corrosion (Not Lower Than)	D 130	IB
Oxidation Stability (Not Less Than)	D 525	240+
Hydrocarbon Composition	D1319	---
Olefins, Percent, Max.	-----	30
Aromatics, Percent, Max.	-----	40
Saturates	-----	Remainder
Nitrogen, Wt. Percent, Max (chemically bound + additive introduced: determined by Kjeldahl method)	-----	0.03

For computation purposes, the lower heating values of this fuel is to be assumed as 18 100 Btu/lb. An A. P. I. gravity of 56.0 is to be assumed in all calculations.

TABLE III

CHRYSLER TURBINE ENGINE　　FACILITY SEX4　　PROGRAM C002　　READING NO.

2) ENGINEERING UNITS (CORRECTED)

P1	P2	P2A	P4	P5	P6	P6A	P68	P8
COMP. INLET PRESS, PSIA	COMP. DISCH. PRESS, PSIA	COMP. DISCH. PRESS, PSIA	COMB. INLET PRESS. PSIA	TURB. INLET PRESS, PSIA	TURBINE INTER STAGE POS #1 PSIA	POS #2 PSIA	PRESSURE POS # PSIA	TURB. DISCH. PRESS, PSIA
PIGN	PNOZ		PEXH,L	PEXH,R			TA	TF
IGNITOR COOLANT, PSIA	NOZZLE AIR, PSIA		EXH. PRESS LT., PSIA	EXH. PRESS RT, PSIA			ORIFICE AIR TEMP, °F	FUEL TEMP, °F

T1 = TEMP. COMP. INLET
T2 = TEMP. COMP. DISCH
T5 = TEMP. TURBINE INLET
T6 = TEMP. TURBINE INTERSTAGE
T8 = TEMP. TURBINE DISCHARGE
TEXH,R = TEMP. EXHAUST, RIGHT SIDE
TEXH,L = TEMP. EXHAUST, LEFT SIDE

NGGP	ND	QAL	QAR	QF	TORQ
% GAS GEN SPEED	DYNO SHAFT SPEED, RPM	INLET AIR FLOW LT, CFM	INLET AIR FLOW RT, CFM	FUEL FLOW GAL/HR	TORQUE DYNO LB-FT

CALCULATED VALUES (CORRECTED)

K	WF	WA	F/A	HCC				
PRESSURE RATIO COMP.	FUEL FLOW LB/SEC	INLET AIR FLOW LB/SEC	FUEL-AIR RATIO	NOT USED				
THETA	DELTA	EFPT	NP	HPNET	SFC	T1	T8	NGGEQ
CORR. FACTOR TEMPERATURE	CORR. FACTOR PRESSURE	POWER TURB EFFICIENCY, %	POWER TURB SPEED, RPM	OUTPUT SHAFT POWER, HP	LB/BHP-HR	TEMP CORRECTED °F	MATCH TEMP °F	SPEED, GAS GEN, MATCH 100% R.P.M.

4) EXTERNAL HEAT BALANCE
ENGINEERING UNITS

PE	F1	F2	TCI	TCO	TI	TO	TBP	TTO
COOLANT AIR IN PRESS, PSIA	COOLANT AIR FLOW LT, CFM	COOLANT AIR FLOW RT, CFM	OIL TEMP IN °F	OIL TEMP OUT °F	COOLANT AIR TEMP IN, °F AVGE	COOLANT AIR TEMP OUT, °F AVGE	TEMP BULKHD OUT °F	TEMP EXHAUST + BULKHD FLOW °F
FO								
OIL FLOW GPH								

TI = COOLANT AIR TEMP IN, °F - SIX POSITIONS
TO = COOLANT AIR TEMP OUT, °F - FOUR POSITIONS
TBP = BULKHEAD TEMP OUT, °F
TTO = EXHAUST + BULKHEAD TEMP, °F
TE = ENGINE SURFACE TEMPS, TE1 THRU TE 8　SEE INSTRUMENTATION SKETCH FOR LOCATION
TE9 THRU TE 16

CALCULATED VALUES

WT	WBP	WEXH	WHL1	WHL2	WHL	WO	
TOTAL ENGINE FLOW LB/SEC	BULKHEAD FLOW LB/SEC	ENGINE EXH FLOW LB/SEC	COOLANT AIR FLOW LT LB/SEC	COOLANT AIR FLOW RT LB/SEC	COOLANT AIR FLOW LB/SEC	OIL FLOW LB/HR	
QHF	QHA	QEXH	QSH	QO	QHL	QBP	HTB
HEAT INPUT FUEL BTU/HR	ENTHALPY X WT. FLOW OF INLET AIR BTU/HR	HEAT LOSS EXHAUST BTU/HR	WORK SHAFT BTU/HR	HEAT LOSS OIL BTU/HR	HEAT LOSS HOUSING BTU/HR	HEAT LOSS BULKHEAD BTU/HR	HEAT BALANCE ERROR PERCENT

CHRYSLER TURBINE ENGINE　　FACILITY SEX4　　PROGRAM C002　　READING 11

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2) ENGINEERING UNITS (CORRECTED)

P1	P2	P2A	P4	P5	P6	P6A	P6B	P8
14.696	22.295	22.173	22.060	21.467	16.858	16.867	16.935	14.892

PIGN	PNCZ		PEXH,L	PEXH,P			TA	TF
23.471	25.546		14.618	14.616			69.738	66.701

T1 =	85.020	85.020				
T2 =	179.40	180.33	178.00	177.45		
T5 =	1420.2	1384.8	1408.6	1412.5		
T6 =	1354.1	1348.8	1359.8			
T8 =	1307.4	1295.4	1293.3	1308.5		
TEXH,P=	300.56	307.90	306.11	301.97	300.56	298.49
TEXH,L=	306.01	306.77	306.11	308.27	308.93	306.67

NGGP	ND	QAL	QAS	QF	TORQ
49.955	1300.0	302.52	305.23	2.1870	32.559

CALCULATED VALUES (CORRECTED)

K	WF	WA	F/A	HCC
1.5129	0.39073E-02	0.77342	0.50519E-02	12.593

THETA	DELTA	EFPT	NP	HPNET	SFC	T1	T8	NGGEQ
0.93662	0.97832	94.181	12594.	8.0589	1.7454	85.020	1301.2	43173.

4) EXTERNAL HEAT BALANCE
ENGINEERING UNITS

PF	F1	F2	TCI	TCO	TI	TO	TBP	TTO
14.221	465.18	518.35	81.554	135.79	66.677	81.973	462.08	256.85

FO
56.929

TI =	66.372	64.807	64.405	68.249	68.204	68.025		
TC =	86.383	81.243	80.622	79.646				
TBP =	462.73	461.49	462.02					
TTO =	257.56	257.38	255.62					
TE =	394.25	342.47	460.07	515.55	414.13	419.87	207.81	-22.751
	187.33	150.48	189.23	236.08	189.15	158.16	452.59	241.95

CALCULATED VALUES

WT	WPP	WEXH	WHL1	WHL2	WHL	WO
0.78554	0.17017E-02	0.78384	0.54997	0.61283	1.1628	701.69

CHF	QHA	QEXH	QSH	QO	QHL	QBP	HTB
0.24104E 06	4246.2	0.13349E 06	19419.	17151.	15239.	0.66866	24.456

CHRYSLER TURBINE ENGINE　　FACILITY SEX4　　PROGRAM C002　　READING 13

2) ENGINEERING UNITS (CORRECTED)

P1	P2	P2A	P4	P5	P6	P6A	P6B	P8
14.696	26.534	26.503	26.289	25.491	18.372	18.378	18.474	14.972

PIGN	PNOZ		PEXH,L	PEXH,R			TA	TF
28.242	30.247		14.610	14.633			69.469	65.226

T1 =	85.308	85.020				
T2 =	216.63	217.28	215.61	214.41		
T5 =	1471.5	1429.8	1464.2	1465.4		
T6 =	1377.4	1368.0	1381.7			
T8 =	1311.0	1293.3	1297.2	1313.0		
TEXH,R=	341.04	347.22	345.60	343.70	343.13	339.62
TEXH,L=	349.69	350.74	349.69	351.69	351.88	349.41

NGGP	NP	QAI	QAR	QF	TORQ
60.119	1757.7	390.17	389.86	3.2158	53.446

CALCULATED VALUES (CORRECTED)

K	WF	WA	F/A	HCC
1.8045	0.57471E-02	0.98917	0.58101E-02	17.599

THETA	DELTA	EFPT	NP	HPNET	SFC	T1	T8	NGGEQ
0.93894	0.97771	76.607	17027.	17.886	1.1567	85.020	1304.9	43227.

4) EXTERNAL HEAT BALANCE
ENGINEERING UNITS

PF	F1	F2	TCI	TCO	TI	TO	TBP	TTO
14.215	482.01	518.85	85.586	148.22	67.437	87.310	478.34	295.52

FP
110.23

TI =	67.579	65.389	64.942	68.874	69.008	68.829		
TO =	91.952	85.498	84.700	87.091				
TBP =	478.43	478.25	478.34					
TTO =	296.51	295.97	294.10					
TF =	411.70	353.83	478.51	529.10	419.69	427.14	224.98	109.20
	206.60	174.71	209.42	252.45	210.34	184.25	448.05	256.37

CALCULATED VALUES

WT	WBP	WEXH	WHL1	WHL2	WHL	WO
1.0035	-0.12085E-01	1.0156	0.56406	0.60718	1.1712	796.68

QHF	QHA	QEXH	QSH	QO	QHL	QBP	HTB
0.35476E 06	6069.6	0.21007E 06	43126.	22601.	19944.	23.331	18.034

CHRYSLER TURBINE ENGINE   FACILITY SSX4   PROGRAM C002   READING 28

2) ENGINEERING UNITS (CORRECTED)

P1	P2	P2A	P4	P5	P6	P6A	P6B	P8
14.696	45.651	49.608	49.287	47.568	24.988	25.094	25.203	15.625

PIGN	PNOZ		PEXH,L	PEXH,R			TA	TF
54.435	55.865		14.917	14.911			75.173	62.138

T1 =	85.445	85.020				
T2 =	371.02	370.93	370.36	365.72		
T5 =	1632.8	1588.5	1661.3	1658.3		
T6 =	1455.1	1435.1	1449.2			
T8 =	1308.5	1291.2	1290.8	1304.0		
TEXH,R=	508.42	510.39	513.10	514.03	513.00	509.36
TEXH,L=	524.39	526.06	525.04	524.67	524.11	522.90

NGGP	ND	QAL	QAR	QF	TORQ
90.003	3213.8	785.44	770.38	9.8299	162.94

CALCULATED VALUES (CORRECTED)

K	WF	WA	F/A	HCC
3.3784	0.17580E-01	1.9357	0.90818E-02	38.385

THETA	DELTA	EFPT	NP	HPNET	SFC	T1	T8	NGGEQ
0.95025	0.96546	70.164	31133.	99.705	0.63475	85.020	1298.6	43486.

4) EXTERNAL HEAT BALANCE
ENGINEERING UNITS

PE	F1	F2	TCI	TCO	TI	TO	TBP	TTO
14.167	-1.2966	989.05	101.29	190.97	71.817	115.33	542.52	461.25

FO
147.32

TI =	71.996	70.748	69.186	72.664	72.976	73.332		
TO =	117.95	107.75	114.89	120.71				
TBP =	541.77	542.99	542.81					
TTO =	461.49	460.87	461.40					
TE =	551.19	393.80	150.35	578.22	444.30	474.26	316.38	-184.32
	304.19	299.10	307.32	343.55	302.27	292.18	453.62	309.43

CALCULATED VALUES

WT	WBP	WEXH	WHL1	WHL2	WHL	WO
1.5337	-0.21310	2.1468	-0.14385E-02	1.0973	1.0959	1057.8

QHF	QHA	QEXH	QSH	QD	QHL	CBP	HTB
0.10780E 07	18852.	0.77554E 06	0.23881E 06	43799.	40852.	1566.7	-0.33723

CHRYSLER TURBINE ENGINE FACILITY SEX4 PROGRAM C002 READING 31

2) ENGINEERING UNITS (CORRECTED)

P1	P2	P2A	P4	P5	P6	P6A	P6B	P8
14.696	54.455	54.164	54.154	52.473	25.750	26.052	25.946	15.804

PIGN	PNOZ	PEXH,L	PEXH,R	TA	TF
59.654	61.085	14.978	14.983	74.728	60.121

T1	=	85.304	85.020				
T2	=	402.91	402.24	401.20	396.72		
T5	=	1654.9	1616.2	1689.1	1685.5		
T6	=	1460.8	1437.8	1452.8			
T8	=	1306.9	1289.4	1283.3	1298.1		
TEXH,R	=	543.13	545.36	547.69	547.87	545.83	543.13
TEXH,L	=	557.80	559.94	558.73	557.71	556.97	555.67

NGGR	ND	QAL	QAR	QF	TORQ
94.962	3431.1	857.23	847.18	11.374	182.68

CALCULATED VALUES (CORRECTED)

K	WF	WA	F/A	HCC
3.6955	0.20350E-01	2.1212	0.95934E-02	42.642

THETA	DELTA	EFPT	NP	HPNET	SFC	T1	T8	NGGEQ
0.54835	0.96383	71.014	33239.	119.34	0.61388	85.020	1294.4	43443.

4) EXTERNAL HEAT BALANCE
ENGINEERING UNITS

PE	F1	F2	TCI	TCO	TI	TO	TBP	TTC
14.175	11.725	998.97	104.33	199.69	72.478	124.13	563.95	492.18

FC
152.52

TI	=	72.753	71.282	69.766	73.154	73.555	74.356		
TO	=	124.02	117.34	125.77	129.39				
TBP	=	563.55	564.33	563.98					
TTC	=	492.29	491.94	492.29					
TS	=	564.85	403.25	556.06	594.78	451.52	486.03	335.49	-232.89
		323.97	321.81	328.42	362.50	324.33	310.37	461.53	323.65

CALCULATED VALUES

WT	WBP	WEXH	WHL1	WHL2	WHL	WO
2.1185	-0.23785	2.3564	0.12820E-01	1.0922	1.1050	1093.9

QHE	QHA	QEXH	QSH	QO	QHL	QBP	HTB
0.12445E 07	21833.	0.91609E 06	0.28507E 06	48343.	48905.	1577.8	-2.6553

CHRYSLER TURBINE ENGINE FACILITY SFX4 PROGRAM C002 READING 35

2) ENGINEERING UNITS (CORRECTED)

P1	P2	P2A	P4	P5	P6	P6A	P6B	P8
14.696	60.918	60.772	60.512	58.563	27.376	27.566	27.544	16.056

PIGN	PNOZ	PEXH,L	PEXH,R	TA	TF
65.065	67.942	15.097	15.094	74.728	58.461

T1 =	85.828	85.020				
T2 =	439.36	439.17	438.60	432.41		
T5 =	1756.4	1710.5	1788.3	1785.3		
T6 =	1540.9	1511.9	1534.9			
T8 =	1367.5	1345.3	1339.7	1350.5		
TEXH,R=	588.56	592.25	594.10	593.64	590.87	588.37
TEXH,L=	602.86	604.15	602.96	602.13	601.39	600.83

NGGR	WF	QAL	QAR	QF	TORQ
100.06	2712.7	925.98	930.09	13.560	209.92

CALCULATED VALUES (CORRECTED)

K	WF	WA	F/A	HCC
4.1403	0.24270E-01	2.3133	0.10491E-01	47.642

THETA	DELTA	TFPT	NP	HPNET	SFC	T1	T8	NGGEQ
0.94613	0.95974	72.622	35967.	148.39	0.58878	85.020	1350.7	43392.

4) EXTERNAL HEAT BALANCE
ENGINEERING UNITS

PC	F1	F2	TCI	TCO	TI	TO	TBP	TTO
14.193	-0.94612E-01	981.94	108.36	211.03	73.918	140.18	598.01	533.15

FO
160.58

TI =	74.490	73.020	70.970	74.356	74.579	76.091		
TO =	139.31	133.18	142.19	146.05				
TBP =	597.55	598.41	598.06					
TTO =	533.29	532.68	533.47					
TF =	596.94	423.28	503.83	628.12	470.45	508.32	364.08	149.91
	346.84	351.31	355.86	385.77	343.82	335.85	482.63	345.94

CALCULATED VALUES

WT	WBP	WEXH	WHL1	WHL2	WHL	WO
2.3052	-0.26894	2.5741	-0.10073E-03	1.0455	1.0454	1149.7

QHF	QHA	QEXH	QSH	QO	QHL	QBP	HTR
0.14762E 07	26553.	0.10965E 07	0.35256E 06	54967.	59349.	1679.4	-4.1469

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2) ENGINEERING UNITS (CORRECTED)

P1	P2	P2A	P4	P5	P6	P6A	P6B	P8
14.696	22.220	22.150	21.975	21.301	16.841	16.863	16.915	14.886

PIGN	PNOZ	PEXH,L	PEXH,R	TA	TF
22.956	25.438	14.614	14.617	67.461	63.973

T1 =	85.020	85.020				
T2 =	179.63	180.76	178.49	178.02		
T5 =	1428.2	1389.4	1416.9	1416.9		
T6 =	1360.7	1353.6	1364.4			
T8 =	1309.1	1298.3	1296.9	1308.9		
TEXH,R=	303.77	309.96	307.87	303.77	304.16	301.97
TEXH,L=	310.53	311.68	311.01	312.25	312.82	310.72

NGGP	ND	QAL	QAR	QF	TORQ
49.846	1251.0	297.59	299.98	2.2590	33.152

CALCULATED VALUES (CORRECTED)

K	WF	WA	F/A	HCC
1.5109	0.40384E-02	0.77127	0.52361E-02	12.649

THETA	DELTA	EFPT	NP	HPNET	SFC	T1	T8	NGGEQ
0.92335	0.97894	99.732	12119.	7.8965	1.8411	85.020	1303.3	42866.

4) EXTERNAL HEAT BALANCE
ENGINEERING UNITS

PE	F1	F2	TCI	TCO	TI	TO	TBP	TTO
14.253	45.036	628.44	80.089	133.96	65.545	84.910	445.31	251.63

FC
94.997

TI =	65.121	64.271	63.107	66.462	67.087	67.221		
TO =	98.374	84.523	83.061	83.682				
TBP =	445.91	445.02	445.02					
TTO =	252.98	251.74	250.16					
TE =	413.05	348.51	765.54	150.00	415.03	418.53	208.25	154.99
	187.41	148.70	188.28	233.06	186.11	157.68	437.29	243.62

CALCULATED VALUES

WT	WBP	WEXH	WHL1	WHL2	WHL	WO
0.78953	0.85598E-02	0.78097	0.53077E-01	0.74063	0.79371	688.11

CHE	QFA	QEXH	QSH	QO	QHL	QBP	HTB
0.24752E 06	3505.7	0.12825E 06	18904.	16676.	13169.	16.012	29.482

CHRYSLER TURBINE ENGINE FACILITY SEX4 PROGRAM C002 READING 46

2) ENGINEERING UNITS (CORRECTED)

P1	P2	P2A	P4	P5	P6	P6A	P6B	P8
14.696	26.548	26.373	26.179	25.410	18.385	18.397	18.495	15.003

PIGN	PNOZ	PEXH,L	PEXH,R	TA	TF
28.249	20.287	14.652	14.660	69.380	66.478

T1	=	85.117	85.020				
T2	=	216.84	217.58	215.63	214.32		
T5	=	1468.4	1430.0	1467.4	1465.5		
T6	=	1379.2	1370.0	1380.6			
T8	=	1311.1	1300.2	1296.7	1312.3		
TEXH,R=		346.16	351.62	350.09	347.12	347.59	345.10
TEXH,L=		351.91	351.91	350.85	352.87	353.06	351.53

NGGP	NP	QAL	QAP	QF	TORQ
59.851	1700.5	402.86	385.21	3.3473	56.712

CALCULATED VALUES (CORRECTED)

K	WF	WA	F/A	HCC
1.8005	0.59806E-02	1.0078	0.59344E-02	17.611

THETA	DELTA	EFPT	NP	HPNET	SFC	T1	T8	NGGEQ
0.93032	0.97608	77.609	16473.	18.362	1.1726	85.020	1305.1	43028.

4) EXTERNAL HEAT BALANCE
ENGINEERING UNITS

PB	F1	F2	TCI	TCO	TI	TO	TBP	TTO
14.223	50.603	631.59	81.332	146.40	67.831	92.304	464.69	292.28

FO
106.19

TI	=	66.819	66.695	65.121	68.963	69.721	69.677		
TO	=	95.878	89.346	90.230	93.762				
TBP	=	464.60	464.69	464.77					
TTO	=	293.12	292.58	291.15					
TF	=	451.61	362.50	484.70	197.78	422.21	430.99	226.94	149.91
		207.47	172.46	210.08	252.89	209.12	183.29	438.19	258.79

CALCULATED VALUES

WT	WBP	WEXH	WHL1	WHL2	WHL	WO
1.0255	-0.76693E-02	1.0331	0.58715E-01	0.73283	0.79155	768.79

QHF	QHA	QEXH	QSH	QO	QHL	QBP	HTB
0.36686E 06	6546.4	0.20990E 06	43995.	22537.	16597.	8.7054	21.523

CHRYSLER TURBINE ENGINE FACILITY SEX4 PROGRAM C002 READING 49

2) ENGINEERING UNITS (CORRECTED)

P1	P2	P2A	P4	P5	P6	P6A	P6B	P8
14.696	32.161	32.120	31.822	30.957	20.326	20.320	20.449	15.161

PIGN	PNOZ	PEXH,L	PEXH,P	TA	TF
36.003	36.445	14.681	14.697	71.298	65.673

T1 =	85.692	85.020				
T2 =	261.38	261.75	260.26	257.48		
T5 =	1527.3	1466.6	1531.1	1529.5		
T6 =	1403.0	1394.5	1406.2			
T8 =	1314.8	1297.8	1300.1	1312.8		
TEXH,P=	393.67	397.23	397.61	396.27	396.56	393.67
TEXH,L=	404.15	404.73	403.00	403.48	403.67	402.90

NGGP	ND	QAL	QAR	QF	TORQ
69.798	2240.7	487.51	485.19	4.7923	82.894

CALCULATED VALUES (CORRECTED)

K	WF	WA	F/A	HCC
2.1870	0.85638E-02	1.2313	0.69553E-02	23.562

THETA	DELTA	EEPT	NP	HPNET	SFC	T1	T8	NGGEQ
0.93811	0.97363	71.862	21706.	35.364	0.87177	85.020	1306.4	43208.

4) EXTERNAL HEAT BALANCE
ENGINEERING UNITS

PF	F1	F2	TCI	TCO	TI	TC	TBP	TTO
14.217	46.952	636.24	87.135	160.58	69.468	102.68	491.97	343.85

FO
118.68

TI =	68.516	68.338	66.507	70.837	71.104	71.505		
TC =	105.60	95.878	101.73	107.53				
TBP =	491.24	492.56	492.12					
TTO =	344.36	343.91	343.28					
TE =	486.65	377.39	307.77	554.32	436.26	451.88	254.74	124.07
	238.71	211.90	237.08	280.88	240.90	214.65	444.26	267.45

CALCULATED VALUES

WT	WBP	WEXH	WHL1	WHL2	WHL	WO
1.2458	-0.23187E-01	1.2690	0.53496E-01	0.72429	0.77779	857.21

QHE	QHA	QEXH	QSH	QO	QHL	CBP	HTB
0.52619E 06	9679.9	0.31772E 06	84874.	28571.	22136.	56.126	15.398

CHRYSLER TURBINE ENGINE FACILITY SEX4 PROGRAM C002 READING 51

2) ENGINEERING UNITS (CORRECTED)

P1	P2	P2A	P4	P5	P6	P6A	P6B	P8
14.696	32.182	31.946	31.751	30.796	20.301	20.289	20.418	15.139

PIGN	PNOZ	PEXH,L	PEXH,R	TA	TF
35.796	36.155	14.677	14.703	70.897	64.558

T1 =	85.501	85.020				
T2 =	261.07	261.72	260.79	257.72		
T5 =	1525.7	1483.7	1527.6	1532.7		
T6 =	1406.3	1399.2	1410.4			
T8 =	1317.0	1299.5	1301.4	1316.1		
TEXH,R=	393.55	396.53	396.15	395.38	395.95	393.26
TEXH,L=	403.46	403.94	402.40	402.89	403.56	402.69

NGGR	ND	QAL	QAR	QF	TORQ
70.023	2249.9	485.87	493.63	4.7606	80.892

CALCULATED VALUES (CORRECTED)

K	WF	WA	F/A	HCC
2.1818	0.85085E-02	1.2402	0.68606E-02	73.576

THETA	DELTA	FEPT	NP	HPNET	SFC	T1	T8	NGGEQ
0.93646	0.97424	73.120	21796.	34.652	0.88395	85.020	1308.5	43169.

4) EXTERNAL HEAT BALANCE
ENGINEERING UNITS

PF	F1	F2	TCI	TCO	TI	TO	TBP	TTO
14.171	27.283	1433.5	85.188	158.46	70.159	89.143	488.27	343.43

FC
117.70

TI =	70.658	67.489	66.249	71.550	71.327	71.684		
TO =	96.803	87.533	84.878	87.356				
TBP =	487.53	488.94	488.32					
TTC =	344.09	343.46	342.74					
TS =	431.16	334.27	150.09	527.26	417.99	438.86	239.67	149.91
	230.70	203.77	229.34	273.73	236.25	210.82	443.41	271.47

CALCULATED VALUES

WT	WBP	WEXH	WHL1	WHL2	WHL	WO
1.2566	-0.10003E-01	1.2666	0.31633E-01	1.6620	1.6937	850.75

QHF	QHA	QEXH	QSH	QO	QHL	QBP	HTB
0.52266E 06	10504.	0.31488E 06	83143.	28219.	27547.	10.231	14.886

CHRYSLER TURBINE ENGINE — FACILITY SEX4 — PROGRAM C002 — READING 54

2) ENGINEERING UNITS (CORRECTED)

P1	P2	P2A	P4	P5	P6	P6A	P6B	P8
14.696	39.885	39.638	39.412	38.166	22.637	22.603	22.770	15.314

PIGN	PNOZ		PEXH,L	PEXH,R			TA	TF
44.395	44.755		14.777	14.779			72.813	64.510

T1 =	85.498	85.020				
T2 =	312.39	313.14	312.10	308.25		
T5 =	1590.7	1536.3	1595.9	1591.6		
T6 =	1431.7	1420.1	1430.1			
T8 =	1314.6	1295.8	1295.8	1309.2		
TEXH,R =	446.95	449.63	451.45	451.64	450.21	447.05
TEXH,L =	462.53	464.16	462.82	462.82	462.34	461.01

NGGR	NP	QAL	QAR	QF	TORQ
80.031	2792.6	619.78	615.02	6.9311	118.04

CALCULATED VALUES (CORRECTED)

K	WF	WA	F/A	HCC
2.7056	0.12389E-01	1.5548	0.79682E-02	30.495

THETA	DELTA	SFPT	MP	HPNET	SFC	T1	T8	NGGEO
0.94158	0.97138	70.456	27053.	62.762	0.71063	85.020	1303.9	43287.

4) EXTERNAL HEAT BALANCE
ENGINEERING UNITS

PE	F1	F2	TCI	TCO	TI	TO	TBP	TTO
14.125	0.35159	1443.4	92.791	172.50	70.553	95.024	509.05	397.52

FO
130.73

TI =	70.257	67.981	68.427	72.486	72.129	72.040		
TO =	103.27	90.593	90.274	95.966				
TBP =	509.40	508.55	509.20					
TTO =	397.85	397.40	397.31					
TS =	472.49	347.25	493.26	539.76	422.56	457.49	267.45	165.09
	259.14	241.12	258.04	300.57	265.72	244.93	438.32	291.20

CALCULATED VALUES

WT	WBP	WEXH	WHL1	WHL2	WHL	WO
1.5681	-0.74204E-01	1.6423	0.40314E-03	1.6551	1.6555	942.02

QHE	QHA	QEXH	QSH	QO	QHL	QBP	HTB
0.76088E 06	12620.	0.49384E 06	0.15056E 06	34313.	34709.	337.28	7.8424

CHRYSLER TURBINE ENGINE FACILITY SEX4 PROGRAM C002 READING 57

2) ENGINEERING UNITS (CORRECTED)

P1	P2	P2A	P4	P5	P6	P6A	P6B	P8
14.696	49.525	49.359	49.059	47.516	24.972	25.111	25.245	15.650

PIGN	PNOZ	PEXH,L	PEXH,P	TA	TF
54.122	55.655	14.934	14.916	72.591	61.197

T1 =	85.640	85.020				
T2 =	370.28	370.95	370.09	365.52		
T5 =	1641.1	1555.3	1666.5	1661.9		
T6 =	1458.7	1441.1	1453.7			
T8 =	1312.1	1294.8	1295.4	1305.6		
TEXH,P=	510.11	511.90	514.54	516.24	513.98	510.49
TEXH,L=	525.46	527.80	526.30	525.64	524.89	523.48

NCCP	ND	QAL	QAS	QE	TORQ
89.898	3238.2	765.57	761.39	9.8431	161.32

CALCULATED VALUES (CORRECTED)

K	WF	WA	F/A	HCC
3.3643	0.17607E-01	1.9162	0.91885E-02	38.335

THETA	DELTA	EEPT	NP	HPNET	SFC	T1	T8	NGGEQ
0.94373	0.96587	70.722	31370.	99.464	0.63727	85.020	1302.0	43337.

4) EXTERNAL HEAT BALANCE
ENGINEERING UNITS

PE	F1	F2	TCI	TCO	TI	TO	TBP	TTO
14.119	11.335	1453.6	98.125	188.37	71.021	103.58	535.77	456.72

FO
143.14

TI =	70.346	69.008	68.025	73.154	72.931	72.664		
TO =	110.60	98.125	99.577	106.04				
TBP =	535.22	536.27	535.83					
TTO =	456.86	456.60	456.69					
TF =	523.93	366.38	150.17	555.10	426.33	474.00	299.41	151.34
	255.36	283.85	293.34	334.63	298.69	280.79	445.82	310.37

CALCULATED VALUES

WT	WBP	WEXH	WHL1	WHL2	WHL	WO
1.9217	-0.19965	2.1214	0.12794E-01	1.6408	1.6535	1029.1

QHE	QFA	QEXH	QSH	QO	QHL	QBP	HTB
0.10764E 07	17435.	0.75637E 06	0.23752E 06	42716.	46135.	1352.7	0.89471

CHRYSLER TURBINE ENGINE FACILITY SEX4 PROGRAM C002 READING 61

2) ENGINEERING UNITS (CORRECTED)

P1	P2	P2A	P4	P5	P6	P6A	P6B	P8
14.696	54.762	54.700	54.440	52.664	25.874	26.198	26.123	15.840

PIGN	PNO7		PEXH,L	PEXH,R			TA	TF
59.394	61.327		15.023	14.997			72.903	60.390

T1	=	85.878	85.020				
T2	=	403.38	403.67	403.28	397.45		
T5	=	1671.3	1628.4	1699.9	1695.3		
T6	=	1469.4	1445.6	1463.0			
T8	=	1313.3	1295.2	1290.7	1305.6		
TEXH,R	=	545.11	548.38	550.63	550.91	547.82	545.20
TEXH,L	=	559.50	560.71	559.59	558.19	557.63	557.35

NCGR	NC	QA1	QA2	DF	TORQ
94.908	3476.4	851.52	846.20	11.535	178.66

CALCULATED VALUES (CORRECTED)

K	WF	WA	F/A	HCC
3.7242	0.20637E-01	2.1271	0.97021E-02	42.794

THETA	DELTA	EFPT	NP	HPNET	SFC	T1	T8	NGGEQ
0.94324	0.96281	71.127	33678.	118.26	0.62823	85.020	1301.2	43325.

4) EXTERNAL HEAT BALANCE
ENGINEERING UNITS

PE	F1	F2	TCI	TCO	TI	TO	TBP	TTO
14.103	35.257	1463.1	102.92	197.52	70.925	109.78	555.45	488.88

FO
151.99

TI	=	69.855	69.141	69.677	72.798	72.085	71.996		
TO	=	116.34	104.11	106.30	112.40				
TBP	=	554.53	555.99	555.45					
TTO	=	489.03	488.59	489.03					
TE	=	545.61	377.30	539.41	570.15	432.42	483.82	319.07	166.57
		320.73	305.93	312.79	354.28	322.89	306.65	455.57	323.16

CALCULATED VALUES

WT	WBP	WEXH	WHL1	WHL2	WHL	WO
2.1230	-0.25129	2.3793	0.39318E-01	1.6316	1.6709	1090.7

QHE	QHA	QEXH	QSH	QO	QHL	QBP	HTR
0.12573E 07	19124.	0.91734E 06	0.28143E 06	47733.	55632.	1617.0	-2.1371

CHRYSLER TURBINE ENGINE   FACILITY SEX4   PROGRAM C002   READING 65

2) ENGINEERING UNITS (CORRECTED)

P1	P2	P2A	P4	P5	P6	P6A	P6B	P8
14.696	60.926	60.864	60.542	58.576	27.404	27.632	27.592	16.022

PIGN	PNOZ		PEXH,L	PEXH,R			TA	TF
65.721	68.134		15.091	15.081			74.639	60.569

T1 =	85.448	85.020				
T2 =	438.68	436.97	436.87	431.34		
T5 =	1753.9	1706.4	1785.3	1781.1		
T6 =	1539.5	1508.9	1532.1			
T8 =	1364.9	1342.9	1338.8	1350.1		
TEXH,R=	586.32	585.29	592.15	592.43	588.82	586.32
TEXH,L=	602.87	605.27	603.98	602.96	601.95	600.56

NGGP	NP	QAL	QAR	QF	TORQ
100.08	3706.5	925.68	908.85	13.705	209.88

CALCULATED VALUES (CORRECTED)

K	WF	WA	F/A	HCC
4.1437	0.24518E-01	2.2919	0.10698E-01	47.446

THETA	DELTA	FEPT	NP	HPNET	SFC	T1	T8	NGGEQ
0.94514	0.96158	71.859	35906.	148.12	0.59592	85.020	1349.2	43369.

4) EXTERNAL HEAT BALANCE
ENGINEERING UNITS

PE	F1	F2	TCI	TCO	TI	TO	TBP	TTO
14.093	-2.8030	1479.3	108.54	206.25	73.480	120.21	588.69	528.54

FO
160.80

TI =	72.174	71.862	71.416	75.291	74.935	75.201		
TO =	125.46	114.06	118.61	122.72				
TBP =	588.28	589.15	588.63					
TTO =	528.66	528.22	528.75					
TF =	536.03	396.59	564.68	595.71	445.46	499.08	342.69	149.96
	343.82	337.92	338.01	278.24	334.54	329.09	472.40	344.18

CALCULATED VALUES

WT	WPP	WEXH	WHL1	WHL2	WHL	WO
2.2898	-0.43561	2.7254	-0.30729E-02	1.6188	1.6158	1151.2

QHF	QHA	QEXH	QSH	QO	QHL	CBP	HTB
0.14934E 07	25520.	0.11566E 07	0.35239E 06	52393.	64696.	3856.9	-7.3058

CHRYSLER TURBINE ENGINE FACILITY SEX4 PROGRAM C002 READING 87

2) ENGINEERING UNITS (CORRECTED)

P1	P2	P2A	P4	P5	P6	P6A	P6B	P8
14.696	22.254	22.151	22.007	21.408	16.860	16.863	16.918	14.925

PIGN	PNOZ	PEXH,L	PEXH,R	TA	TF
23.327	25.566	14.602	14.602	74.105	72.765

T1 =	85.545	85.020				
T2 =	178.68	175.79	177.30	176.74		
T5 =	1419.3	1380.6	1407.1	1410.3		
T6 =	1354.9	1347.2	1357.8			
T8 =	1304.4	1293.5	1291.1	1304.4		
TEXH,R=	301.27	306.70	304.08	299.68	301.08	299.68
TEXH,L=	308.20	308.85	308.10	309.70	310.54	308.38

NGGP	NP	QAL	QAR	QF	TORQ
49.808	1248.0	306.40	309.34	2.1900	33.583

CALCULATED VALUES (CORRECTED)

K	WF	WA	F/A	HCC
1.5108	0.39073E-02	0.77221	0.50599E-02	12.505

THETA	DELTA	EFPT	NP	HPNET	SFC	T1	T8	NGGEQ
0.94258	0.96934	99.671	12090.	7.9798	1.7627	85.020	1298.3	43310.

4) EXTERNAL HEAT BALANCE
ENGINEERING UNITS

PF	F1	F2	TCI	TCO	TI	TO	TBP	TTO
13.953	942.59	967.42	81.953	133.70	72.655	82.749	452.24	262.53

FO
98.188

TI =	71.951	69.989	70.524	75.424	75.068	72.976		
TO =	87.887	81.909	80.178	81.021				
TBP =	452.59	451.97	452.15					
TTO =	263.29	262.94	261.35					
TE =	357.53	294.10	417.54	481.52	384.06	416.10	196.17	87.843
	188.97	148.13	180.13	230.87	187.33	154.21	436.76	238.31

CALCULATED VALUES

WT	WBP	WEXH	WHL1	WHL2	WHL	WO
0.77467	0.38440E-02	0.77083	0.97599	1.1206	2.0966	710.68

QHE	QHA	QEXH	QSH	QO	QHL	CBP	HTB
0.23959E 06	8135.2	0.13479E 06	19112.	16582.	18132.	3.2102	23.857

CHRYSLER TURBINE ENGINE FACILITY SEX4 PROGRAM C002 READING 84

2) ENGINEERING UNITS (CORRECTED)

P1	P2	P2A	P4	P5	P6	P6A	P6B	P8
14.696	26.359	26.462	26.184	25.462	18.321	18.339	18.441	15.002

PIGN	PNOZ		PEXH,L	PEXH,R			TA	TF
27.957	30.184		14.602	14.612			73.259	71.967

T1 =	84.829	85.020				
T2 =	215.56	216.67	214.74	213.63		
T5 =	1465.6	1420.5	1457.3	1460.8		
T6 =	1374.5	1366.3	1378.6			
T8 =	1307.9	1295.8	1294.5	1311.2		
TEXH,R =	341.71	346.54	344.36	342.47	343.89	340.95
TEXH,L =	348.44	345.68	347.97	345.68	350.44	348.35

NGGP	ND	CAL	QAR	OF	TORQ
55.935	1698.3	407.31	392.29	3.2832	54.481

CALCULATED VALUES (CORRECTED)

K	WF	WA	F/A	HCC
1.7971	0.58589E-02	1.0018	0.58485E-02	17.488

THETA	DELTA	EEPT	NP	HPNET	SFC	T1	T8	NGGEQ
0.94183	0.97016	78.400	16452.	17.617	1.1973	85.020	1302.3	43293.

4) EXTERNAL HEAT BALANCE
ENGINEERING UNITS

PE	F1	F2	TCI	TCO	TI	TO	TBP	TTO
13.965	844.10	958.26	94.435	144.70	72.633	84.001	462.73	296.89

EQ
109.11

TI =	71.461	69.855	71.684	74.667	74.534	73.599		
TO =	85.567	83.239	81.243	81.953				
TBP =	462.38	463.09	462.73					
TTO =	297.49	297.13	296.06					
TE =	365.54	300.26	431.43	422.56	379.46	421.94	210.60	153.47
	205.08	169.99	159.52	246.65	207.38	181.26	433.04	241.47

CALCULATED VALUES

WT	WBP	WEXH	WHL1	WHL2	WHL	WC
1.0070	-0.15012E-01	1.0220	0.97633	1.1084	2.0847	788.93

QHE	QHA	QEXH	QSH	QO	QHL	QBP	HTB
0.35942E 06	10548.	0.21286E 06	42213.	21505.	20304.	32.467	19.745

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CHRYSLER TURBINE ENGINE FACILITY SEX4 PROGRAM C002 READING 91

2) ENGINEERING UNITS (CORRECTED)

P1	P2	P2A	P4	P5	P6	P6A	P6B	P8
14.696	32.144	32.081	31.916	30.850	20.277	20.274	20.410	15.171

PIGN	PNOZ		PEXH,L	PEXH,R			TA	TF
35.446	36.605		14.679	14.685			73.971	69.559

T1 =	85.115	85.020				
T2 =	260.26	260.53	259.14	256.65		
T5 =	1512.3	1468.0	1518.3	1516.8		
T6 =	1396.7	1387.8	1401.5			
T8 =	1308.4	1291.0	1292.1	1306.1		
TEXH,R=	388.46	391.14	291.05	391.05	392.00	389.13
TEXH,L=	401.01	402.44	400.81	401.01	401.10	399.67

NGGP	NO	QAL	QAR	QF	TORQ
69.952	2246.6	494.32	492.18	4.8183	80.954

CALCULATED VALUES (CORRECTED)

K	WF	WA	F/A	HCC
2.1851	0.86029E-02	1.2695	0.67765E-02	23.420

THETA	DELTA	SEPT	NP	HPNET	SFC	T1	T8	NGGEO
0.94175	0.96607	73.544	21764.	34.629	0.89436	85.020	1299.4	43291.

4) EXTERNAL HEAT BALANCE

ENGINEERING UNITS

PF	F1	F2	TCI	TCO	TI	TO	TBP	TTO
13.937	849.21	963.22	86.737	156.20	72.834	87.661	482.85	342.59

FO
118.55

TI =	71.817	70.480	71.416	74.890	74.890	73.510		
TO =	95.834	85.808	83.106	85.896				
TBP =	482.14	483.38	483.02					
TTO =	343.28	342.56	341.53					
TE =	420.32	314.23	452.15	191.88	390.73	441.00	231.31	150.04
	228.08	200.95	223.67	271.16	233.36	198.26	433.58	256.32

CALCULATED VALUES

KT	WBP	WEXH	WHL1	WHL2	WHL	WO
1.2719	-0.30862E-01	1.3027	0.57372	1.1044	2.0781	856.38

QHE	QFA	QEXH	QSH	QO	QHL	QBP	HTR
0.52551E 06	13525.	0.32542E 06	82623.	26983.	26400.	91.697	14.380

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CHRYSLER TURBINE ENGINE            FACILITY SEX4            PROGRAM C002            READING  95

 2)  ENGINEERING UNITS (CORRECTED)
       P1          P2          P2A          P4          P5          P6          P6A          P6B          P8
     14.696      39.596      39.596      39.409      38.093      22.529      22.501      22.672      15.377

      PIGN        PNOZ                   PEXH,L      PEXH,R                                 TA          TF
     44.540      44.727                  14.745      14.773                              72.903      66.254

     T1     =   85.403      85.020
     T2     =   312.41      312.88      311.47      307.90
     T5     =   1584.0      1533.7      1599.3      1592.4
     T6     =   1429.3      1417.4      1427.9
     T8     =   1310.7      1295.3      1294.2      1308.7
     TEXH,R=    446.41      449.00      451.68      452.35      449.67      446.89
     TEXH,L=    461.43      463.34      461.53      461.24      460.48      459.71

      NGGP        NP          QAL         QAP         QF          TORQ
     79.939      2786.6      635.13      620.85      7.1428      114.95

     CALCULATED VALUES (CORRECTED)
       K           WF          WA          F/A         HCC
     2.6943     0.12763E-01  1.5717     0.81202E-02  30.453

      THETA       DELTA       EFPT        NP          HPNET       SFC         T1          T8          NGGEQ
     0.94076     0.96485     71.568      26995.      60.989      0.75333     85.020      1302.2      43268.

 4)  EXTERNAL HEAT BALANCE
     ENGINEERING UNITS
       PE          F1          F2          TCI         TCO         TI          TO          TBP         TTO
     13.963      852.67      967.27      92.526      169.21      73.294      92.244      507.67      397.79

       FD
     130.91

     TI     =   71.684      70.748      72.708      75.291      75.201      74.134
     TO     =   101.03      90.583      86.958      90.407
     TBP    =   507.00      508.23      507.79
     TTC    =   398.21      397.76      397.40
     TC     =   448.32      326.98      473.20      273.47      404.51      459.27      256.98      152.30
                256.85      239.32      254.47      300.75      263.29      229.21      436.98      281.59

     CALCULATED VALUES
       WT          WBP          WEXH        WHL1        WHL2        WHL         WC
     1.5754     -0.49002E-01  1.6244      0.97137     1.1019      2.0733      943.42

      QHF          QHA          QEXH        QSH          QO          QHL         QBP         HTB
     0.77820E 06   17353.     0.48632E 06  0.14526E 06  33048.      33663.      146.50      12.208
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CHRYSLER TURBINE ENGINE FACILITY SEX4 PROGRAM C002 READING 98

2) ENGINEERING UNITS (CORRECTED)

P1	P2	P2A	P4	P5	P6	P6A	P6B	P8
14.696	49.404	49.155	48.997	47.381	24.898	25.042	25.157	15.659

PIGN	PNOZ	PEXH,L	PEXH,R	TA	TF
54.918	55.554	14.905	14.926	74.861	65.942

T1 =	85.401	85.020				
T2 =	371.21	371.11	369.97	365.78		
T5 =	1635.8	1586.2	1738.5	1660.6		
T6 =	1452.7	1437.0	1448.4			
T8 =	1309.1	1292.7	1290.9	1304.2		
TEXH,R=	509.44	510.86	514.44	516.14	513.50	510.10
TEXH,L=	524.98	527.23	525.54	524.41	523.85	522.53

NGGP	ND	QAL	QAR	QF	TORQ
90.144	3247.1	767.56	769.93	9.7794	159.34

CALCULATED VALUES (CORRECTED)

K	WF	WA	F/A	HCC
3.3546	0.17475E-01	1.9146	0.91270E-02	38.377

THETA	DELTA	EEPT	NP	HPNET	SFC	T1	T8	NGGEQ
0.94365	0.95934	70.260	31457.	98.515	0.63857	85.020	1299.2	43335.

4) EXTERNAL HEAT BALANCE
ENGINEERING UNITS

PF	F1	F2	TCI	TCO	TI	TO	TBP	TTO
13.947	857.19	967.87	95.570	185.20	73.836	99.118	535.01	456.00

FO
141.47

TI =	71.951	71.104	73.421	75.735	75.869	74.935		
TO =	109.77	96.451	92.835	97.420				
TBP =	534.61	535.48	534.95					
TTO =	456.24	455.90	455.98					
TF =	489.39	342.65	496.79	150.17	419.96	472.93	295.30	150.48
	287.99	282.96	291.73	232.68	296.64	269.35	445.02	314.72

CALCULATED VALUES

WT	WBP	WEXH	WHL1	WHL2	WHL	WO
1.9071	-0.19873	2.1058	0.96340	1.0878	2.0512	1018.3

QHF	QHA	QEXH	QSH	QC	QHL	CBP	HTB
0.10611E 07	21864.	0.74949E 06	0.23365E 06	41848.	44433.	1349.2	1.1230

CHRYSLER TURBINE ENGINE | FACILITY SEX4 | PROGRAM C002 | READING 101

2) ENGINEERING UNITS (CORRECTED)

P1	P2	P2A	P4	P5	P6	P6A	P6B	P8
14.696	54.722	54.597	54.367	52.580	25.797	26.148	26.054	15.887

PIGN	PNOZ		PEXH,L	PEXH,R			TA	TF
59.988	61.335		14.997	14.994			73.081	63.168

T1 =	85.546	85.020				
T2 =	403.33	403.81	403.04	397.86		
T5 =	1674.4	1622.7	1697.3	1693.0		
T6 =	1471.8	1447.2	1462.6			
T8 =	1311.4	1295.4	1290.2	1304.6		
TEXH,R=	544.34	546.60	549.42	550.45	547.54	544.91
TEXH,L=	559.92	561.98	560.29	559.54	558.89	558.04

NGGR	ND	QAL	QAR	QF	TORQ
94.954	3451.5	850.14	843.77	11.465	179.38

CALCULATED VALUES (CORRECTED)

K	WF	WA	F/A	HCC
3.7193	0.20459E-01	2.1158	0.96887E-02	42.797

THETA	DELTA	FEPT	NP	HPNET	SFC	T1	T8	NGGEQ
0.94026	0.95729	72.721	33437.	117.88	0.62603	85.020	1300.4	43257.

4) EXTERNAL HEAT BALANCE
ENGINEERING UNITS

PF	F1	F2	TCI	TCO	TI	TO	TBP	TTO
13.941	860.05	972.82	97.596	193.09	74.355	105.26	550.84	486.56

FC
145.65

TI =	72.842	71.505	73.065	76.625	76.491	75.602		
TO =	114.02	101.56	99.841	105.64				
TBP =	550.40	551.19	550.92					
TTO =	486.65	486.38	486.65					
TE =	522.35	348.06	510.51	544.12	428.12	491.94	313.96	163.62
	315.71	306.70	310.10	348.60	321.77	294.59	450.28	332.20

CALCULATED VALUES

WT	WBP	WEXH	WHL1	WHL2	WHL	WO
2.1078	-0.23345	2.3413	0.95568	1.0810	2.0367	1047.5

QHF	QHA	QEXH	QSH	QO	QHL	QBP	HTB
0.12398E 07	25083.	0.89637E 06	0.27848E 06	45979.	53938.	1368.7	-0.88669

CHRYSLER TURBINE ENGINE FACILITY SEX4 PROGRAM C002 READING 104

2) ENGINEERING UNITS (CORRECTED)

P1	P2	P2A	P4	P5	P6	P6A	P6B	P8
14.696	59.249	59.490	59.186	57.448	27.099	27.438	27.328	16.044
PIGN	PNOZ		PEXH,L	PEXH,R			TA	TF
64.391	66.684		15.077	15.084			73.125	62.496

T1 =	85.307	85.020				
T2 =	432.22	430.49	430.87	425.21		
T5 =	1756.1	1700.0	1781.3	1776.8		
T6 =	1537.6	1512.4	1530.4			
T8 =	1361.8	1344.1	1338.6	1352.3		
TEXH,R=	579.26	582.25	584.58	584.58	581.97	579.17
TEXH,L=	595.00	596.77	595.56	594.35	593.51	593.05

NGGR	NP	QAL	QAR	QF	TORQ
99.208	3704.2	895.51	904.88	13.285	201.21

CALCULATED VALUES (CORRECTED)

K	WF	WA	F/A	HCC
4.0398	0.23758E-01	2.2492	0.10563E-01	46.578

THETA	DELTA	EFPT	NP	HPNET	SFC	T1	T8	NGGEQ
0.94026	0.95505	73.134	35884.	141.91	0.60268	85.020	1349.2	43257.

4) EXTERNAL HEAT BALANCE
ENGINEERING UNITS

PF	F1	F2	TCI	TCO	TI	TO	TBP	TTO
13.949	856.44	970.12	191.51	202.86	75.074	112.41	577.39	519.35
FO								
153.97								

TI =	73.154	72.095	74.089	77.380	77.158	76.580		
TO =	122.06	107.18	107.49	112.92				
TBP =	576.92	577.88	577.36					
TTO =	519.38	519.11	519.55					
TE =	554.84	367.46	538.19	556.58	446.71	510.43	332.87	150.00
	336.93	328.10	324.64	368.09	328.78	317.59	464.46	345.04

CALCULATED VALUES

WT	WBP	WEXH	WHL1	WHL2	WHL	WO
2.2373	-0.27655	2.5138	0.94032	1.0651	2.0055	1105.5

QHF	QHA	QEXH	QSH	CO	QHL	CBP	HTB
0.14335E 07	27967.	0.10380E 07	0.33447E 06	51745.	64156.	1623.6	-1.9497

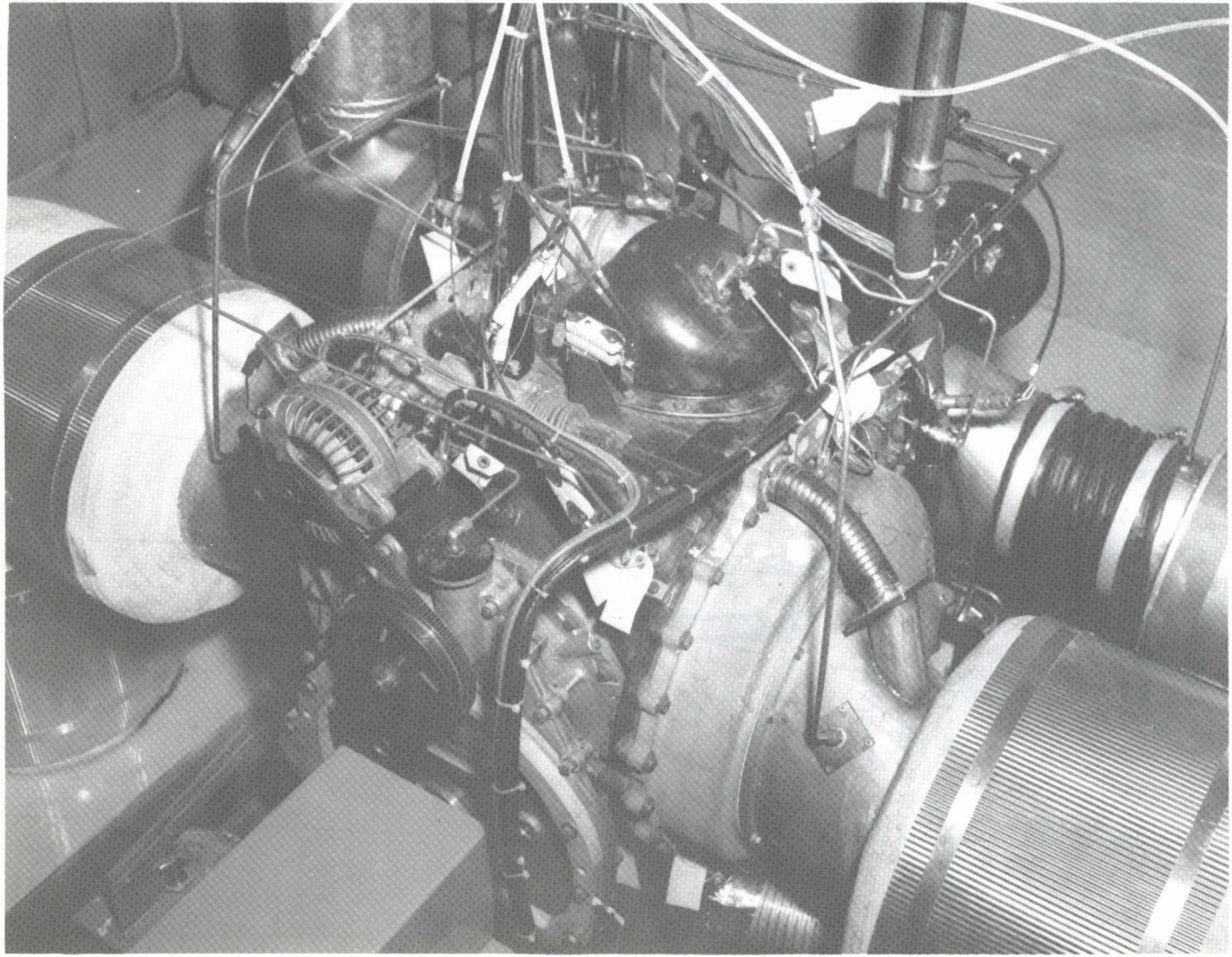

FIGURE 2. PHOTOGRAPH OF INSTRUMENTED GAS TURBINE ENGINE.

FIGURE 1. SCHEMATIC AIR FLOW PATH
GAS TURBINE ENGINE

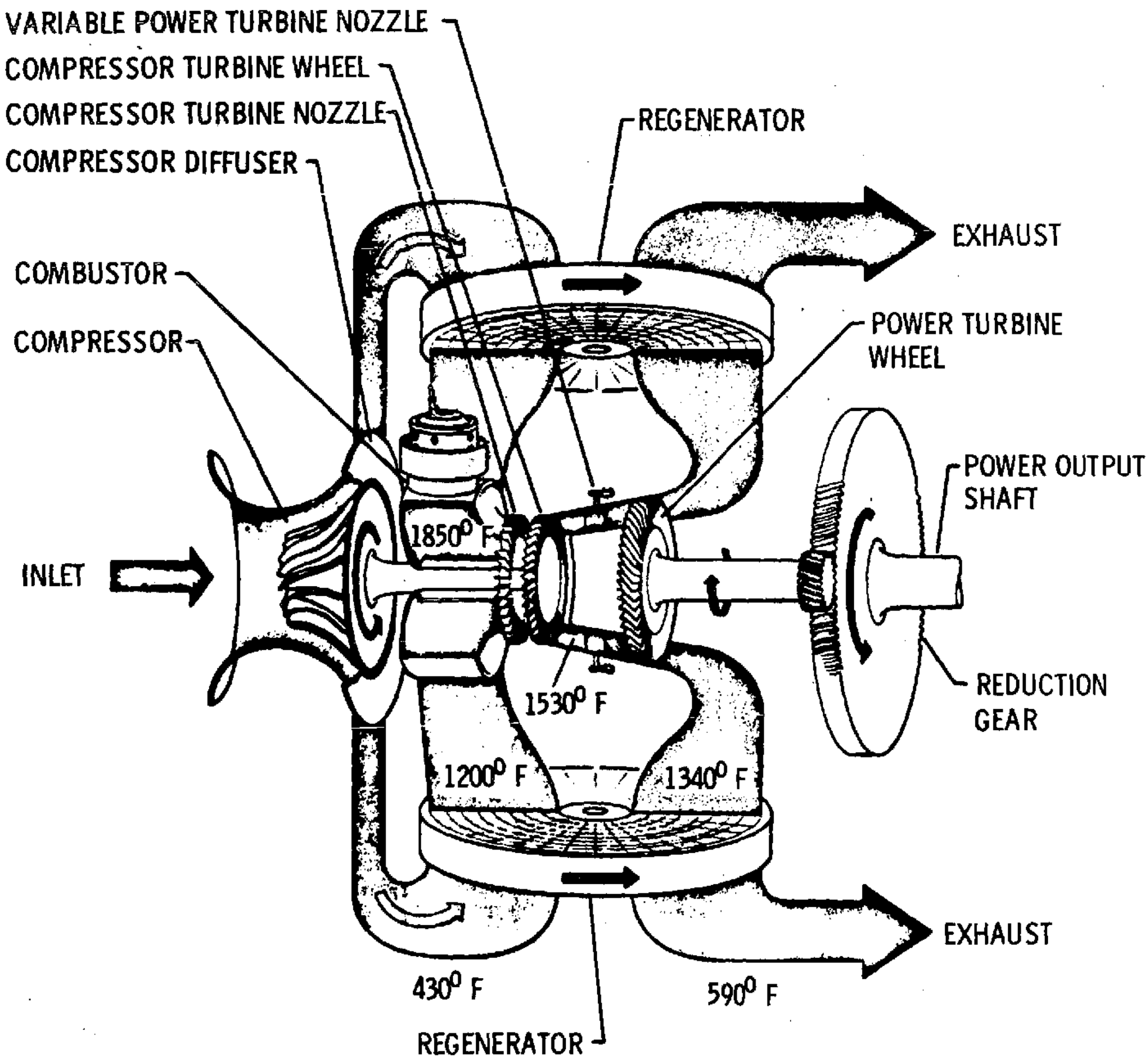

TABLE IV. - COMPARISON OF MEASURED AND CALCULATED VALUES OF TOTAL HEAT LOSS

Reading No.	Percent gas generator speed	Total heat loss measured, QL_m Btu/hr	Total heat loss calculated, QL_c Btu/hr	QL as percent of QHF	
				measured	calculated
11	50	32,390	92,377	13.4	38.3
13	60	42,568	107,634	12.0	30.3
28	90	86,218	82,502	8.0	7.6
31	95	98,826	65,173	7.9	5.2
35	100	115,995	53,693	7.9	3.6
42	50	29,861	103,872	12.0	42.0
46	60	39,143	119,511	10.7	32.6
49	70	50,763	133,276	9.6	25.3
51	70	55,776	135,141	10.7	25.9
54	80	69,359	130,100	9.1	17.1
57	90	90,204	99,945	8.4	9.3
61	95	104,982	77,654	8.3	6.2
65	100	120,946	9,930	8.1	0.7
87	50	34,717	93,823	14.5	48.0
84	60	41,841	114,895	11.6	32.0
91	70	53,475	130,996	10.2	24.9
95	80	66,858	163,973	8.6	21.1
98	90	87,630	99,824	8.3	9.4
101	95	101,286	90,033	8.2	7.3
104	100	117,525	88,997	8.2	6.2

E-8318

NOMENCLATURE

TI TEMPERATURE-INLET
TO TEMPERATURE-OUT
F FLOW
PE PRESSURE
BV BUTTERFLY VALVE
CV CONTROL VALVE
SO SHUT OFF VALVE

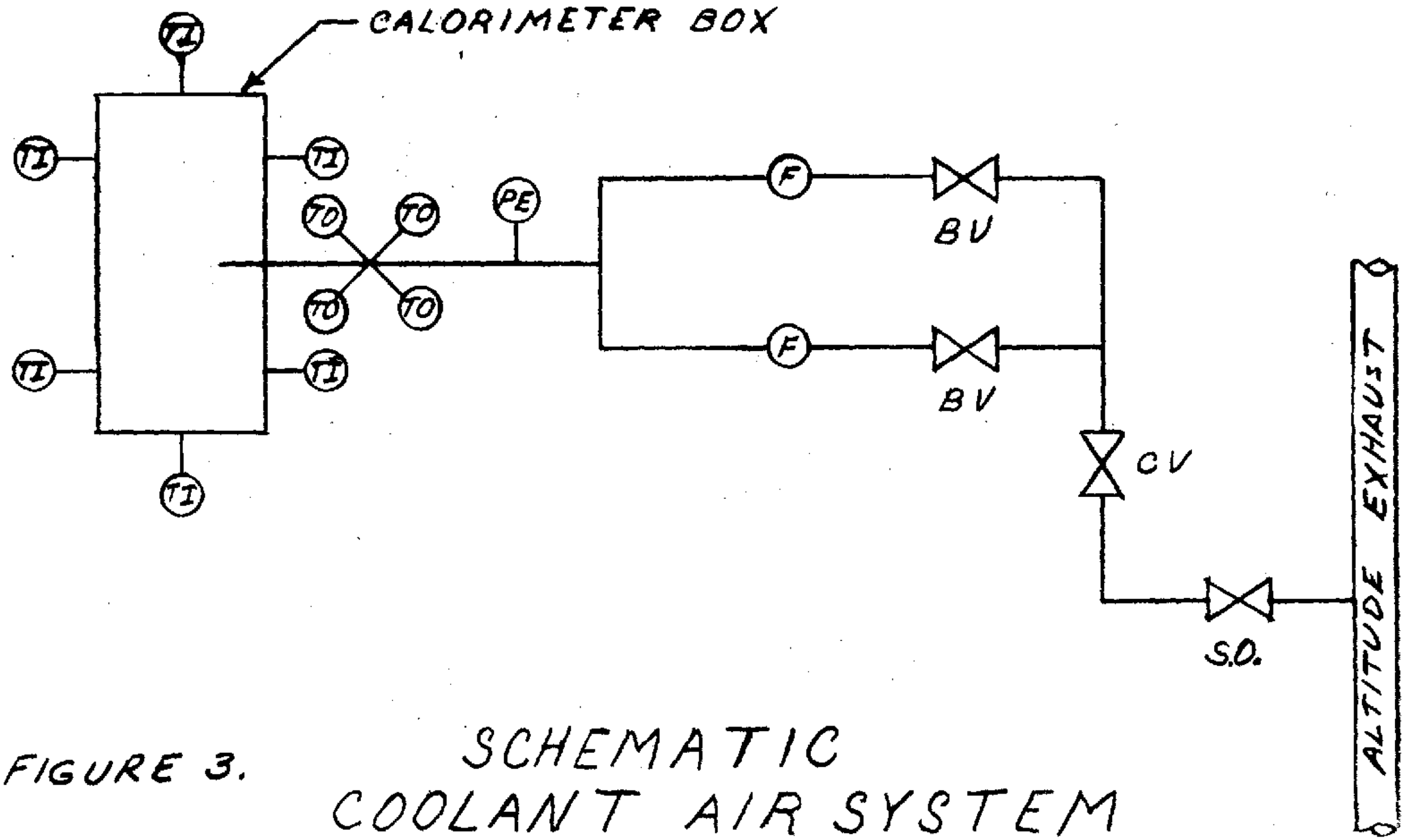

FIGURE 3. SCHEMATIC COOLANT AIR SYSTEM

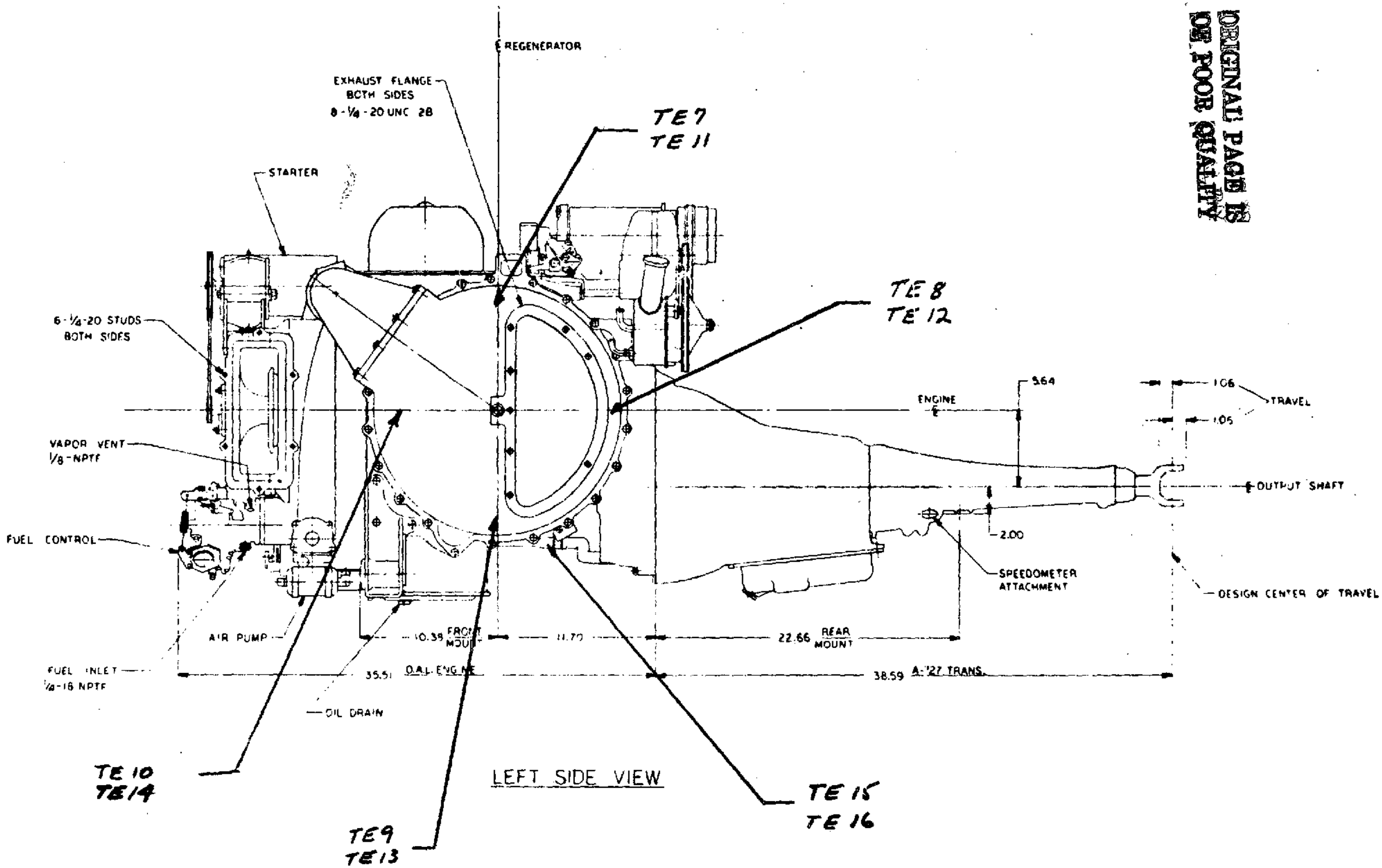

FIGURE 4. SIDE VIEW OF ENGINE SHOWING THEROCOUPLE LOCATIONS FOR BOTH SIDES.

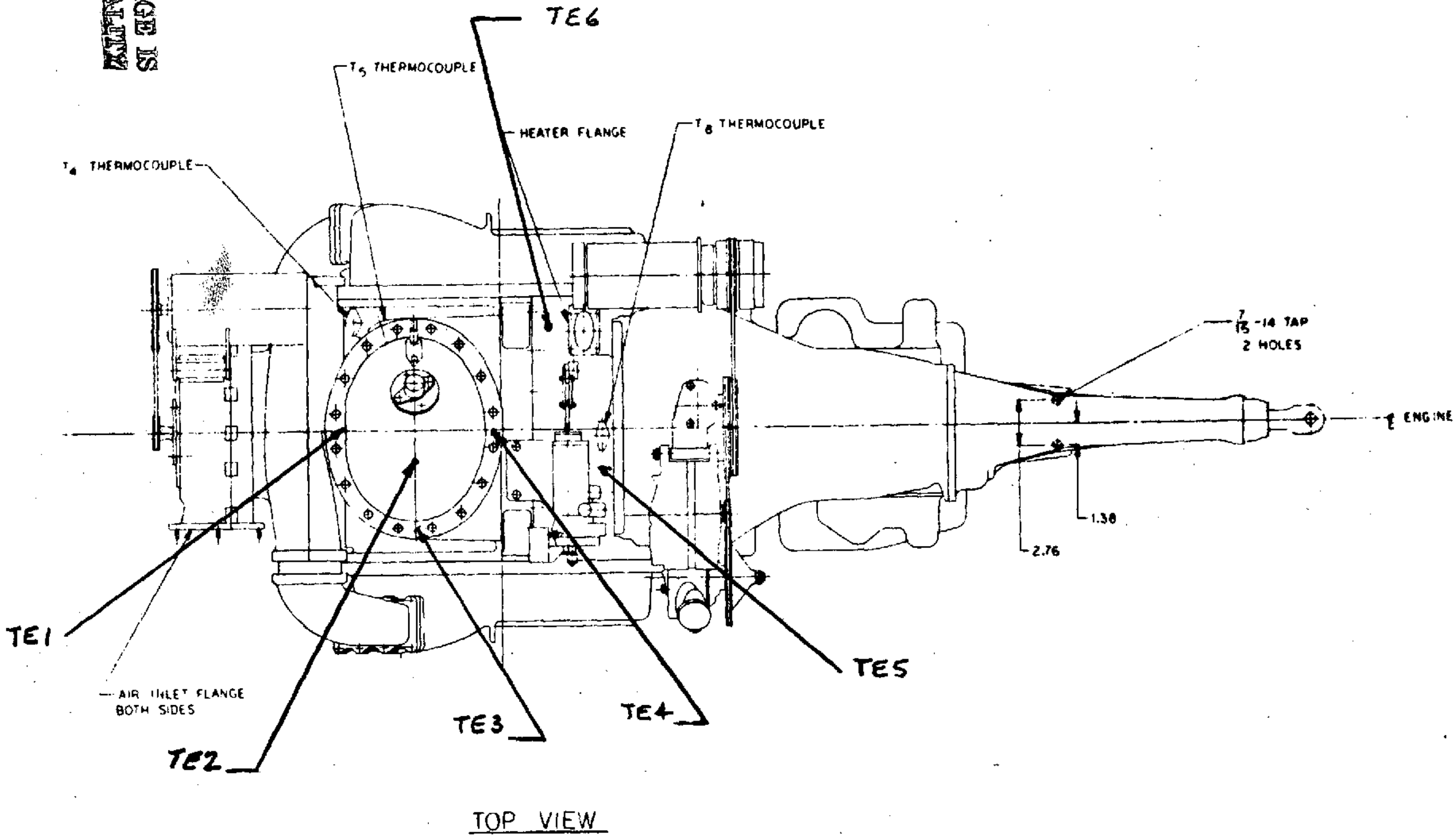

FIGURE 5. TOP VIEW OF ENGINE SHOWING THERMOCOUPLE LOCATIONS.

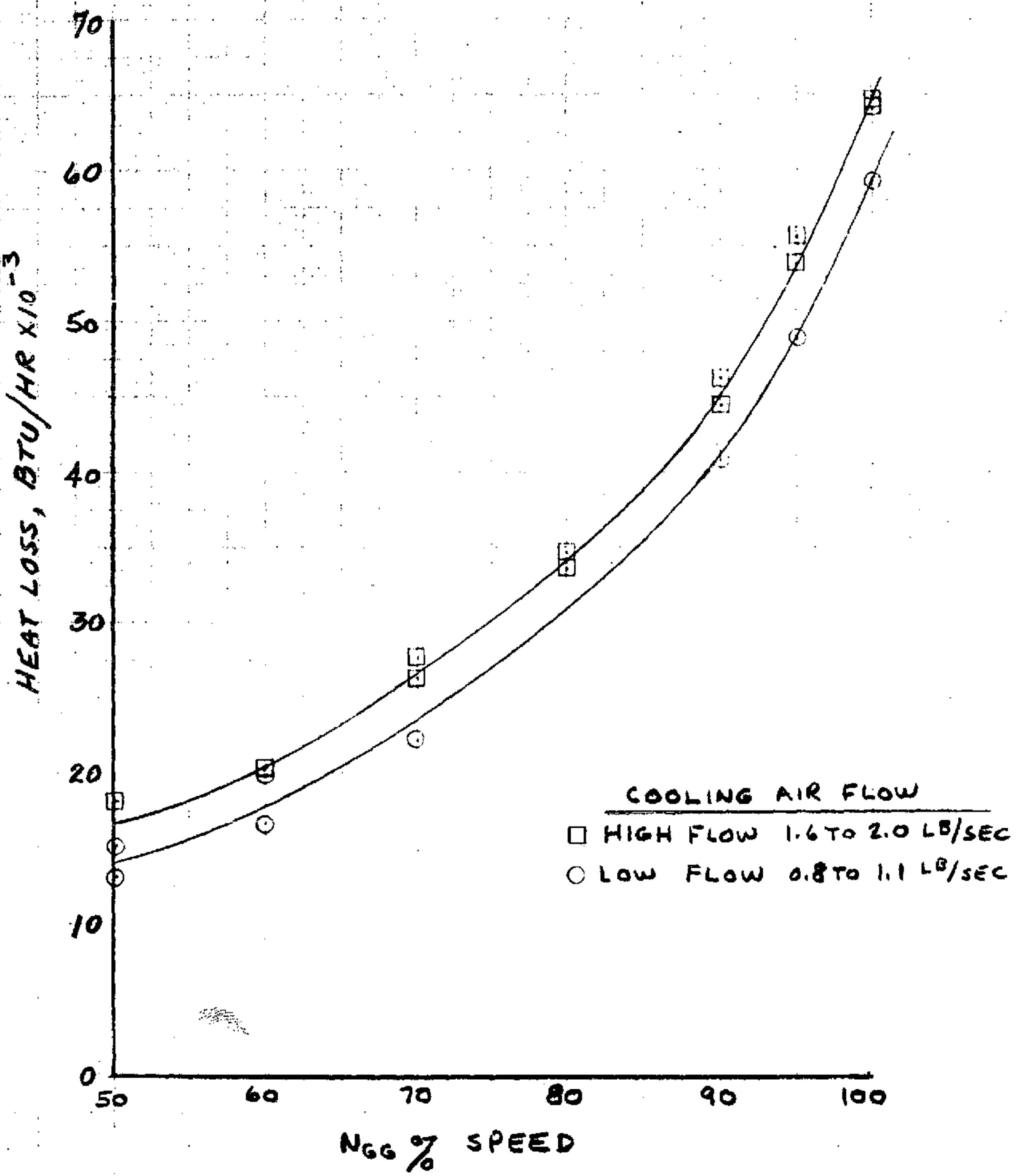

FIG. 6 ENGINE HOUSING HEAT LOSS AS A FUNCTION OF PERCENT GAS GENERATOR SPEED.

PRM 3/14/75